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THE EXTENT OF THE CORDILLERAN ICE-SHEET

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Through the courtesy of members of the United States Forest Service I was enabled, in the summer of 1912, to make some observations upon glaciation in the Kaniksu National Forest in northern Idaho. Because of the inaccessibility of a part of the region and the lack of suitable maps, the work was not complete; but in view of our slight knowledge of the extent and character of the continental glaciation in the northwestern United States, and because the nature of the country makes it extremely unlikely that it will be more carefully studied in the near future, it seems advisable to publish the facts noted. Moreover, there was discovered evidence of more complete reworking of glacial deposits by stream action than has yet been described.

It is known that the front of the Cordilleran ice-sheet was marked by a series of marginal lobes occupying the north-south intermontane valleys of the northwestern United States. The line of crosses in Fig. 1, based on data published by Professor Salisbury,¹ shows the probable extent of some of these lobes. It is believed that the Pend d'Oreille lobe was continuous with that in the Colville valley, but its connection with the Kootenai lobe was well north of Bonners Ferry, and probably north of the International Boundary. In the paper cited nothing is said of the eastern boundary of the Pend d'Oreille lobe, but my observations show that the ice must have covered the divide between the Pend d'Oreille and Priest Lake valleys.

This divide is a range of forest-covered hills having a maximum elevation of 6,500 feet, and an average height a thousand feet less. The former presence of ice on these hills is unmistakably shown by the rounded topography, by *roches moutonnées*, and by glacial striae—in one instance on bedrock, and in others on float. The striae on bedrock strike N. 10° W. Looking east across Priest

¹ *Jour. Geol.*, IX, 721-24.

Lake from the top of this divide to the eastern shore of the lake, one sees the eastern line of the ice clearly marked. From this shore rises a series of hills with a smoothly rounded topography strongly indicating glaciation, but farther in the background is a higher ridge of granite, with a serrated and pinnacled outline in sharp contrast to the gentler slopes of the lower hills. Closer examination of this divide east of Priest Lake valley discloses a series of cirques worn out by valley glaciers tributary to the

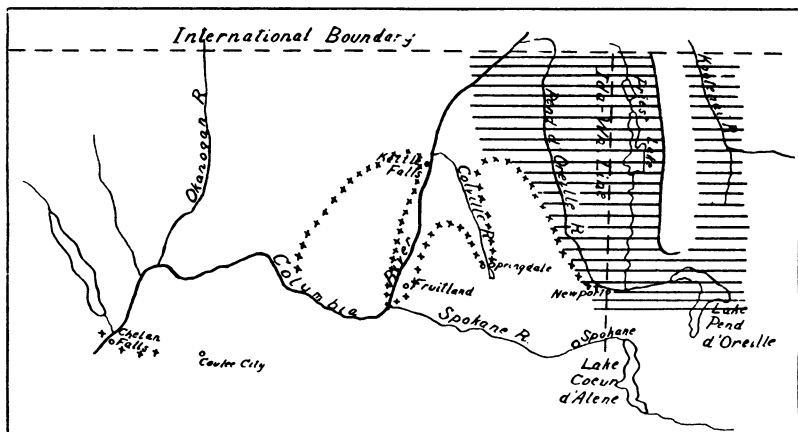


FIG. 1.—Sketch map of a portion of Idaho and Washington. Crosses indicate moraine according to Salisbury. Lined area shows extent of Pend d'Oreille-Priest River marginal lobe.

main ice-sheet. The upper limit of ice in these cirques was about 7,000 feet.¹ The Pend d'Oreille lobe therefore extended eastward as indicated by the lined area on the map.

The basins of Upper and Lower Priest lakes are deep and rock-floored, and suggest in all respects a valley scoured and enlarged by glaciation, and the lakes themselves can be attributed to no other cause than damming by morainal deposits. The country between the Upper and Lower lakes is low and swampy in most places, but deposits of coarse fragmental material are found; the outlet of the Lower Lake flows through a flat valley of sand

¹ All elevations given in this paper are based upon aneroid readings checked on U.S.G.S. elevation for Priest Lake 2,460 feet. As I was often away from this known elevation for several days, there is possibility of considerable error.

and gravel; and the streams flowing into the lake tumble over boulder beds between banks of gravel and sand. It is noteworthy, however, that none of this detrital material—that separating the two lakes, that filling the main valley south of the lower lake, and that in the tributary valleys—shows any sign of morainal topography. It is arranged in terraces, somewhat modified by later erosion, but still forming distinctly flat-topped benches, and the boulders and cobbles found in it indicate, by their partly rounded shape and the lack of striae, wear by water. The obvious conclusion is that upon the retreat of the ice this comparatively narrow valley was filled by a swollen, swiftly flowing stream that completely rearranged the morainal material. Mr. Calkins¹ has noted cases of similar reworking of glacial deposits east of here, but he found traces of true moraine. I know of no description of reworking of glacial deposits by stream action comparable in completeness to that at Priest Lake. An entirely similar condition was found at Sullivan Lake, a small mountain lake in Washington draining into the Pend d'Oreille River.

Having established the former existence of ice over the divide between the Pend d'Oreille and Priest Lake valleys, and its limitation on the east by the Priest Lake-Kootenai divide, we may consider the southern extent of this lobe. The Kootenai lobe probably extended to the southeastern lobe of Lake Pend d'Oreille,² but probably no farther, for there is no evidence of continental glaciation in the Cœur d'Alene Mountains immediately south of this lake. Glacial striae have been found at Cocollala, west of Lake Pend d'Oreille at an elevation of at least 200 feet above the lake.³ It therefore seems probable that the ice of the Kootenai lobe, held back by the Cœur d'Alene Mountains on the south, spread westward down the Pend d'Oreille valley, and united with the Pend d'Oreille-Priest River lobe. The southern limit of the ice formed by the union of these two lobes was somewhere north of the outlet of Lake Cœur d'Alene if the conclusion that the gravel found there is an outwash plain is correct. It is possible, however, that this

¹ *U.S. Geol. Surv. Bull.* 384.

² Calkins, *ibid.*, p. 32.

³ T. C. Chamberlin, *U.S. Geol. Surv.*, 7th Ann. Rept.

material is reworked glacial material similar to that found at Priest Lake, and that the southern boundary of this lobe should be moved farther south. Mr. T. A. Bonser of Spokane, after a series of careful studies, believes that the ice extended at least as far as the city of Spokane, and occupied a part of the Spokane River valley. Until his results are published, however, we cannot definitely locate this southern boundary.

SUMMARY

The conclusions reached above are as follows:

1. The marginal lobe of the Cordilleran glacier occupying the Pend d'Oreille valley passed over the divide on the east and filled Priest Lake valley.
2. Salisbury's opinion is confirmed that if the Kootenai and Pend d'Oreille lobes were offshoots from a continuous sheet, their connection must have been north of the International Boundary.
3. The fronts of these two lobes united to form a continuous sheet of unknown extent to the south.
4. Fluvial reworking of glacial deposits has been so extensive along the front of the Cordilleran ice-sheet that great caution must be used in marking the limits of glaciation. More careful studies will probably show that many localities in the Northwest which now show only the bedded bench gravels characteristic of water-work were at one time actually covered by the ice, and the line of the maximum extent of the Cordilleran glacier will have to be drawn farther south than it is at present.